Nutrition and Geriatric: An Overview

Darshana Choubisa[1]

[1] Geetanjali Dental Research & Institute, Udaipur, Rajasthan, India

Dent J Adv Stud 2022;10:115–127.

Address for correspondence Darshana Choubisa, MDS, Associate Professor, Department of Prosthodontics, Geetanjali Dental and Research Institute, Geetanjali Dental Research & Institute, Udaipur 313001, Rajasthan, India (e-mail: dr.darshanachoubisa@gmail.com).

Abstract

Senescence is marked by several transition in the physique, all of which have a contradictory impact on the well-being and way of living of the geriatric. As a person grows older, nutrition becomes even more important. It has a notable influence on the life quality, including physical and mental health. Food intake decreases due to biological transition in the geriatric, consequently leading to nutritional deficiencies that in turn are the primary possibility for various persistent ailments and degenerating age-related well-being. Intervention can be used to address the ongoing state of dietary deficiency and malnutrition. In this article, an overview between dental health and nutritional condition in geriatric is discussed to aggrandize a healthy way of living in geriatric.

Keywords

- geriatric
- nutrition
- aging
- nutritional analysis

Introduction

In a geriatric population, eating satisfaction is considered an essential factor of quality of life. Today, many people over the age of 65 are either partially or completely edentulous, resulting in reduced masticatory efficiency. This, in turn, causes a shift in their preferred nutrition, which has a significant impact on their health.[1,2]

It is difficult for a dentist to rehabilitate lost masticatory function in a geriatric who is partially or completely edentulous. However, several additional aspects are also important for geriatric nutritional status. Consequently, numerous age-related ailments consist of dietary factors, and the individual socioeconomic condition and dietary habits have a consequential effect on the diet they select.[3]

Understanding nutritional requirements, malnutrition symptoms, and environmental factors influencing food choices will aid dentist identify denture wearers at threat for malnutrition and providing appropriate nutritional counselling. Problems differ by patient and oral health; thus, recommendations must be customized to the patient's individual exigency.[1] The relationship between dental health and nutritional condition in geriatric is discussed in this article.

Nutritional Objectives

1. Establish a balanced diet in accordance with individual physical, societal, mental, and economic conditions.
2. Implement interim nutritional support regimen, aimed at definite objective like caries control, postoperative healing, or tissue conditioning.
3. Assess and institute factors among prosthesis age group population that may aid or impede nutritional treatment.[4]

Age-Related Determinants Influencing Nutritional Requirement

Physiological Determinants

Geriatrics are unable to match recommended nutrient requirements because of their potential to take in adequate

article published online
October 12, 2022

DOI https://doi.org/10.1055/s-0042-1757548.
ISSN 2321-1482.

Thieme Medical and Scientific Publishers Pvt. Ltd., A-12, 2nd Floor, Sector 2, Noida-201301 UP, India

proportion of food decreases with aging. This involuntary physiological depletion in food intake with aging is known as "anorexia."[5]

- As lean body mass declines in geriatric, calorie requirements fall and the danger of falling up increases. The reduction in caloric intake is linked to several factors that make the geriatric anorexia syndrome worse.[6]
- Hormones that influence reduced food consumption include leptin, glucagon-like peptide-1 (GLP-1), cholecystokinin (CCK), ghrelin/hunger hormone, insulin, and peptide YY (PYY). As age progresses, plasma concentration of CCK rises, which causes them to feel full sooner and eat less. GLP-1 and PYY cause the stomach to produce negative signals, which reduce appetite. Low plasma ghrelin levels are linked to aging, which causes gastric emptying to take longer and results in less food intake. In older people with anorexia, low insulin and elevated circulating leptin levels are also linked. Interleukin (IL) 1, IL-6, and tumor necrosis factor α, which are proinflammatory cytokines, slow down gastric emptying and boost leptin levels, which in turn decrease food consumption.[7–10]
- Slowing down of gastric emptying and decrease food consumption is also caused by chronic gastritis, stagnant intestinal motility, reduced gastric secretions, and impaired gallbladder contraction.[5,11]
- Dehydration, which is a major worry in the geriatric and a substantial issue during the prosthetic period due to impaired renal function and total body water metabolism, is a serious issue. Along with discomfort when chewing, many people also feel dryness, unpleasant flavors, oral burning sensations, and pain.[12]
- Numerous nutrient shortages that are frequent in nursing homes, such as zinc and vitamin B6, seem to have an impact on the immune system's function.
- Overt deficiency of several vitamins such as B1, B2, B3, B5, B6, B9, B12, C, and E is linked with neurological and behavioral decline in the geriatric.[13,14]

Psychosocial Determinants

- Geriatric are particularly vulnerable, and at-risk groups include those who are widowed, isolated, depressed, physically disabled with inadequate care, living alone, depressed, have a restrictive diet, and have a low socioeconomic status. Environmental changes are also known to raise stress levels, which can affect dietary patterns and increase the risk of anorexia.[8,15]

Functional Determinants

- Stroke, arthritis, hearing, or vision deterioration can influence nutritional status indirectly.[16,17]

Pharmacological Determinants

- The majority of the geriatric take manifold prescription and over-the-counter medications every day.
- Due to age-related metabolic changes and decreased drug clearance, geriatric patients are more likely to experience negative drug responses. Using more medications also makes this risk worse.
- Prescription medications are the main contributor to anorexia, nausea, vomiting, gastrointestinal problems, xerostomia, taste loss, and disruptions in nutrient uptake and utilization. Nutrient deficits, weight loss, and ultimately malnutrition can result from these conditions.[18,19]

Oral Determinants

Xerostomia

- It can be aftereffect of numerous medications that have a deleterious influence on the tissues that support the dentures.[18]
- It also contributes to anorexia due to chewing and swallowing difficulties, negatively influencing food choice and contributing to penurious nutritional status.[20]

Sense of Taste and Smell

- Changes in olfactory epithelial cells lead to anosmia or hyposmia, while hypogeusia can be because of reduced number and sensitivity of papillae, taste buds, or density of taste buds in the tongue.[21,22]
- Reduced sensory functioning influences food intake both qualitatively and quantitatively in geriatric.[5] It can reduce some foods appeal (e.g., sensitivity to the bitterness of cruciferous vegetables), restricting their consumption and their potential role in well-being.[22]
- Medications, medical conditions, oral hygiene, denture usages, and smoking may be contributing factors to reduced function.[23]

Oral Infectious Conditions

- Susceptibility to periodontal disease increases with aging, and indirectly causes nutritional deficiencies.[24]

Dentulous Status

- Penurious oral health leads to impede masticatory function, additionally causing inappropriate food selection, altering an individual's nutritional intake.[25]
- The presence of natural teeth and well-fitting dentures was shown to be associated with higher and more varied nutrition intakes and higher diet quality.[26,27]

Effects of Dentures

- Ill-fitting dentures restrict geriatric food uptake due to chewing difficulties, which in turn leads to penurious nutritional status.[9]
- In comparison to individual with natural teeth, denture wearer ability to break down food is very penurious. Complete denture wearers require on average four to eight times the number of chewing strokes of dentate persons to attain same degree of pulverization.[28–31]
- Longer chewing and swallowing coarser food particles recompose denture wearer penurious chewing efficiency, which may be due to decrease bite force that denture

wearers can develop due to dearth of denture retention and stability.[32]

- The effect of dentures on nutritional status ranges considerably amidst individuals.
  - ➢ Some geriatric recomposes for reduced chewing efficiency by choosing processed or cooked foods. They are used to chewing it for a prolonged time prior to making it appetizing to swallow.
  - ➢ Others can get rid of whole food groups from their diets because of decreased chewing efficiency.[33]
- Even though the chewing efficiency of complete denture wearers was delineated to be low, ~80% of the complete denture wearers contemplated their self-assessed chewing efficiency to be satisfactroy.[34,35]

Nutritional Consideration for Geriatric Population

The geriatric diet does not have requisite nutrients imperative to perpetuate optimal health and consequently leads to nutrient deficit and progression of degenerative ailments.[36]

Although energy requisite decreases as age progresses because of reduced basal metabolism and physical activity, protein and certain nutrients requisite amplifies for the body normal functioning. The recommended dietary allowances are different for male and female as tabulated in ►**Table 1**.[37,38]

Table 1 Recommended dietary allowances and adequate Intakes, elements food and nutrition board, national academies

	Males (years)		Female (years)	
	51–75	**76**	**51–75**	**76**
Energy (Kcal)	2400	2050	1800	1600
Total water (L/d)	3.7	3.7	2.7	2.7
Nutrients	51–70 years	>70 years	51–70 years	>70 years
Carbohydrates (gm/d)	130	130	130	130
Proteins (gm/d)	56	56	46	46
Total fiber (gm/d)	30	30	21	21
Vitamins				
Vitamin A (µg/d)	900	900	700	700
Vitamin C (mg/d)	90	90	75	75
Vitamin D (µg/d)	15	20	15	20
Vitamin E (mg/d)	15	15	15	15
Vitamin K (µg/d)	120	120	90	90
Thiamin (mg/d)	1.2	1.2	1.1	1.1
Riboflavin (mg/d)	1.3	1.3	1.1	1.1
Niacin (mg/d)	16	16	14	14
Vitamin B6 (mg/d)	1.7	1.7	1.5	1.5
Folate (µg/d)	400	400	400	400
Vitamin B12 (µg)	2.4	2.4	2.4	2.4
Minerals	51–70 years	>70 years		
Calcium (mg/d)	1000	1200	1200	1200
Chromium (µg/d)	30	30	20	20
Copper (µg/d)	900	900	900	900
Iodine (µg/d)	150	150	150	150
Iron (mg/d)	08	08	08	08
Magnesium (mg/d)	420	420	320	320
Manganese (mg/d)	2.3	2.3	1.8	1.8
Molybdenum (µg/d)	45	45	45	45
Phosphorus (mg/d)	700	700	700	700
Zinc (mg/d)	11	11	08	08
Potassium (mg/d)	3,400	3,400	2,600	2,600
Sodium (mg/d)	1500	1500	1500	1500
Chloride (g/d)	2.0	1.8	2.0	1.8

Calories

- The geriatric basal metabolic rate has been found to be decreased by 15 to 20% over their lifetime.[39] This decline is caused by a dropping lean body tissue, which is mostly linked to an atrophy of muscle.[40] The remaining energy expenditure is made up of calories used for work and exercise. The age, on average, limits their lifestyle and exercise less, which leads to muscle mass loss.[41]
- Muscle tissue atrophy occurs as a result of decreasing use. In fact, many studies have shown that exercise can help the geriatric prolong their weight and body constitution.[42,43]
- If calorie balance is still an issue, the older person should simply reduce his or her dietary fat intake. The most nutrition dense calories are fat calories, which may be reinstated with complex carbohydrates, that constitute less calories and a superior nutrient density.[39,44]
- Geriatric obesity is only an issue when their body weight is more than 20% above their ideal body weight. In individual with hyperlipidemia, hypertension, heart disease, diabetes, gout, or arthritis, the first line of treatment should be to maintain a desirable body weight.[38]

Proteins

- In geriatric, there is increase in protein requirement, particularly for indubitable essential amino acids like lysin, cystine, and methionine.[45]
- Insufficient protein consumption leads to muscle mass loss known as sarcopenia, generally, seen among geriatric population due to reduction in daily food intake.[46]
- Lower protein levels also cause edema and affect the bone health and lead to functional loss and brittleness.[47]
- Increase demand for protein is seen in geriatrics with acute or chronic ailments due to their poor anabolic response to protein.[6]
- Comparatively intake of animal protein leads to better muscle mass preservation due to their higher essential amino acid content.[48]

- Adequate source and intake timing of protein and amino acid augmentation improve absorption of protein in geriatric.[49]
- Food sources include poultry, meats, and fish that are boiled and not dried form and dairy products. If consumed in adequate merger, nuts, grains, legumes, and vegetables are of the same quality as protein of animal origin.[48]

Carbohydrates

- Due to low cost, ability to store without refrigeration, and ease of preparation, geriatric patients ingest a substantial portion of their calories as carbohydrates, may be at the levy of protein.
- Despite the fact that carbohydrates account for 45 to 50 % of daily calories, most recommendations encourage raising complex carbohydrates to 55 to 60% of total calories.
- Increasing dietary intake of complex carbohydrates also boosts nutrient intake because starchy foods also include vitamins and minerals. Overall calorie consumption is lowered when carbohydrate items are replaced with more calorie-dense foods, such as those with a higher fat content. Of course, excessive use of any source of calorie may lead to gain in weight, but only some clinical disorders are induced only by carbohydrate intake.[38]
- Two disorders that are linked to poor carbohydrate metabolism in the geriatric: glucose intolerance and lactose intolerance.
- Lactose intolerance is a hereditary disorder in which the enzyme lactase (P-galactosidase) is unable to work normally.[50,51]
- Lactase deficiency prevents the hydrolysis of the lactose (disaccharide) into galactose and glucose. Disaccharide cannot be absorbed; therefore, it goes from the small intestine to the colon and metabolized by intestinal bacteria, causes formation of metabolic by-products like CO2 and lactic acid that disrupt the intestinal osmotic equilibrium, allowing water to enter quickly, resulting in diarrhea. Although lactose intolerance severity varies, the majority of patients will not have symptoms if lactose intake is maintained low.[38]
- Although usually the geriatric patients who are afflicted quickly avoid any form of milk, it's undesirable as milk is rich source of protein, calcium, riboflavin, and other nutrients. Rather than avoiding dairy products, it is recommended that they be consumed in moderation. Smaller amounts of dairy or the usage of milk treated with lactase and fermented milk products are advisable.[52]
- A second issue is the increased prevalence of glucose intolerance in the geriatric, as well as its link to adult-onset diabetes that is seen due to increase in blood glucose and decrease carbohydrate tolerance.[53]
- To balance total calories, it is recommended that intake of complex carbohydrates increases, while fat intake reduces.[40,54]

Dietary Fiber

- It is any food component that reaches the colon without being digested in a healthy human gut.[55]
- Water holding capacity, viscosity, binding, and fermentability are all physical features of fiber that might affect digestion and absorption. The physical characteristics of polysaccharides can alter food digestion and nutrient absorption since small intestine does not digest fiber.[38]
- It's significant from a metabolic standpoint because of its impact on lipid and glucose metabolism. Fibers reduce total serum cholesterol and triglyceride levels by producing short chain fatty acids, which help with lipid metabolism. When it comes to glucose metabolism, fiber might affect glucose or insulin levels, which can lead to a reduction in lipogenic enzymes.[56,57] This activity may be especially beneficial for diabetics due to the depletion in fasting blood glucose and glycosylated hemoglobin, as well as the potential therapeutic benefit in bringing down possibility of coronary heart disease.[58]
- Nondigestible food items, like prebiotics, have a positive effect on the host by encouraging preferential growth and/or activity of one or a small number of bacteria. Impaired colonic bacterial flora and their metabolism can give rise to cytotoxic products that aggrandize chronic inflammation or stimulate mutagenic compounds production, both of which escalate colon cancer risk.[59]
- Fibers are linked to bowel disease and symptoms, and butyrate, in particular, can help keep inflammatory bowel disease remission by stimulating mucosal cell proliferation and speeding up the healing process.
- Give glutamine to colonocytes to promote mucosal barrier fortification thus reducing bacterial translocation across the colonic epithelium and consequent mucosal damage.[60]
- Often, edentulous geriatric population gets gastrointestinal disturbances due to less consumption of food rich in fiber as a result of decreased masticatory efficiency.
- Food sources include whole grain bread, brown rice, whole fruits, legumes, cooked vegetables, fresh salad, and, most importantly, in breakfast high-fiber cereal.[61]

Water

- Water consumption compensates for natural physiological losses, improves digestion and intestinal activity, and facilitates renal clearance. The geriatric must be motivated to drink more water for these reasons.
- Adults are susceptible to negative water balance, either as a result of excessive water loss due to damaged kidneys or fluid retention in an attempt to reduce urination frequency or limit incontinence.[62–64]
- Dehydration in the geriatric will result in nausea, constipation, hypotension, raised body temperature and mucosal dryness, decreased urine output, and mental disorientation. Furthermore, alcohol use, as well as numerous therapeutic medicines, such as diuretic drugs, can accelerate fluid loss.[64,65]
- Due to reduced perception of temperature alterations and mobility, the geriatrics are particularly vulnerable to excessive heat, leading to dehydration and an increase in body temperature.[66] Diabetes, obesity, congestive heart

failure, and obstructive lung disease can all increase the heat stroke risk in geriatric. As a result, it is critical to keep track of fluid balance on a frequent basis.[38]

Vitamins

Vitamin A

- Two forms of vitamin A found in food are β-carotene (provitamin A) found in deep green and yellow fruits and vegetables (apricots, carrots, spinach) and retinol (retinyl esters)/active vitamin A found in animal foods.[67]
- Neurodegeneration, steroid and thyroid hormone physiological function, and eyesight and skin abnormalities are all effects of vitamin A deficiency. In the case of neurodegeneration, all-trans rheumatoid arthritis is protective. In the Alzheimer's disease advancement, it reduces synthesis of amyloid-β peptides and associated oligomerizations.
- Oral changes include reduced salivary flow, desiccation and keratosis of oral mucosa, and reduced taste acuity. Extended deficiency can cause hyperplasia of the gums, as well as generalized gingivitis.[68]

Vitamin B Complex

The vitamin B complex includes eight water-soluble vitamins, which have interdependent roles in maintenance of cell function and brain atrophy.[69,70]

Deficiency, specifically of folate, B6, and B12, is linked to elevated homocysteine levels in serum, which in turn escalate risk of certain ailments such as dementia and Alzheimer's disease.[71]

The repeated usages of laxatives to treat constipation in geriatric population alter metabolism in intestine and alters vitamin B complex absorption.

Animal foods is primary source; hence, its deficiency is more frequent with reduce animal foods intake either due to cultural or religious restrain or high cost.[71,72]

Vitamin B1 (Thiamine)

- Thiamine pyrophosphate is a coenzyme for transketolase, pyruvate dehydrogenase, and α-ketoglutarate dehydrogenase and has anonymous function in nerve impulses propagation and preservation of myelin sheath.
- Its deficit can influence the nervous, immune, and cardiovascular systems, as commonly seen in dry beriberi, Wernicke-Korsakoff syndrome or wet beriberi.[67,73]
- Observed frequently in the poor, institutionalized, and alcoholic segment and area where staple diet are milled cereals and polished rice.[73]
- Food sources include cereals, pasta, whole grains, fortified breads, dried beans, peas, soybeans lean meats, and fish. Fruits, vegetables, and milk products become compelling only when consumed in considerable quantity.[67]

Vitamin B2 (Riboflavin)

- Due its wide food sources, its deficiency is rare.
- Food sources include eggs, lean meats, green leafy vegetables, legumes, nuts, milk products, and fortified breads and cereals.

Vitamin B6 (Pyridoxine)

- Shown link with cardiovascular risk and lipids.[67] Indulged with various metabolic pathways of neural function such as amino acid metabolism, neurotransmitter synthesis and sphingolipid synthesis and breakdown.[74]
- Requirements are more in geriatric due to reduced absorption, raised catabolism, and impaired phosphorylation.[75] It can be a major reason of the heightened pervasiveness of the carpal tunnel syndrome in the geriatrics.[74]
- Deficiency causes nasolabial seborrhea, glossitis, and influences cognitive functioning, accompanied with depressive symptoms frequent in geriatric. It hampers metabolism of serotonin and is an antagonist of P2X receptor. Both are related to the gastrointestinal function, hence may demonstrate link between B6 consumption and symptoms in individual with irritable bowel syndrome.[76]
- Food sources include meat, fish, poultry, fortified cereals, beans, and some fruits and vegetables.[67]

Vitamin B12 (Cobalamin)

- Its deficiency occurs in 5 to 20% of geriatric, but due to its subtle clinical symptoms frequently goes unidentified.[77,78] Causes of the deficiency comprise malabsorption due to degenerative digestive conditions or paucity in intrinsic factor production, pernicious anemia, and inadequate dietary intake.[67]
- Dietary fiber therapy endorsement for constipation treatment curtails laxatives usages and improves vitamin B12 absorption. As its main source is animal food, fortified foods may be a vitamin B12 substitute for vegetarians.[71,72]
- Its deficit may result in megaloblastic anemia and demyelinating neurological symptoms, such as irreversible nerve damage and neuropathy.[79] It has an effect on cognitive functioning, often followed with depressive symptoms prevalent in geriatric.[6] It also showed its association with increase cardiovascular disease risk and bone health.[79] Glossodynia, glossitis, dysgeusia, recurrent ulcers, cheilitis, lingual paresthesia, pruritus, and burning sensations are some of the oral manifestations.[80]
- Food sources include animal foods, such as meat, fish, eggs; milk products; fortified breakfast cereals; and nutritional yeasts.[81–83]

Vitamin B9 (Folate)

- Folate and vitamin B12 are linked with preventing chronic diseases associated with aging via methylation of homocysteine. This is a critical step in averting accumulation of tau and amyloid proteins that may lead to cognitive deterioration.[68]
- Also shown association with an increased cardiovascular risk and bone health when studied alongside B12 insufficiency.[79]
- Inadequate folate status has also been linked to colon cancer.[84]
- Food sources include liver; dark-green leafy vegetables such as turnip greens, and lettuce; broccoli; citrus fruits;

whole grain products; wheat germ; and dried beans and peas.[67]

Vitamin C

- Deficiency in geriatrics has been linked to a severe reduction in physical function, as seen by low muscle mass, weak grip strength, and sluggish walking.[85]
- Research has shown linkage between antioxidants like vitamin A, C, E; and cancer, heart disease, stroke, and arteriosclerosis. Bleeding gums, petechial, slow tissue healing, and painful joints are some of the oral manifestations.[86–89]
- Food sources include citrus fruits, tomatoes, potatoes, and leafy vegetables.[90]

Vitamin D

- As people get older, their vitamin D intake and absorption drop dramatically due to reduced sun exposure, dietary consumption, fat absorption, and conversion into active form of vitamin D.[68]
- Its deficiency impacts calcium homeostasis by reducing intestinal calcium absorption.[6] Its also linked with depression, cancer, cognition, and cardiovascular disease as people age.[91,92] Vitamin D and calcium interact to affect lipid metabolism, neuromodulation, and vasculature.[68]
- Vitamin D enhances clearance of macrophages and phagocytosis, protecting immune cells from apoptosis by modulating extranuclear protein activities as well as gene expression signals.[93]
- Because of lower fractional calcium absorption after menopause, estrogens acceleration on bone loss, and increased urinary calcium losses, women are at an even higher calcium deficiency risk.[68,94]
- Vitamin D3 deficiency is exacerbated by the kidney's failure to transform 25(OH) vitamin D3 to 1,25 (OH) vitamin D and reduced ability of intestine to absorb vitamin D3.[6]
- Serum 25(OH)D levels below 50 nmol/L are linked to reduced muscular strength and physical function in geriatric, while levels below 25 to 30 nmol/L increase the risk of falls and fractures.[95]
- Food sources include fortified milk, fish-liver oil, and saltwater fish. Found in animal foods naturally as the provitamin cholecalciferol.

Vitamin E

- Available in eight different natural forms, including tocotrienols (α, β, gamma, and delta) and tocopherols (α, β, gamma, and delta), all of which are strong antioxidants.
- Although γ-tocopherol is prevalent in human diet, many studies have concentrated on α-tocopherol, available in most over-the-counter adjuncts because its more biologically active.
- Deficiency is uncommon and occurs majorly in conditions that cause fat malabsorption, such as chronic cholestatic liver disease, abetalipoproteinemia, cystic fibrosis and short bowel syndrome.[67]

Vitamin K

- Vitamin K is a multifunctional micronutrient linked to age-related illness like vascular calcification, osteoarthritis, and osteoporosis.[96,97]
- Shown to act as an anti-inflammatory by suppressing nuclear factor κB signal transduction and wielding a protective aftermath against oxidative stress by obstructing generation of reactive oxygen species.[97]
- Food sources include green leafy vegetables: soybean and canola oil.[96]

Minerals

Calcium

- Plays important function in vasodilation, vascular and muscular contraction, intracellular signaling, nerve transmission, and hormone secretion.[98] Vitamin D and calcium are interrelated, influencing lipid metabolism, vasculature, and neuromodulation.[68]
- The aging process is marked by a variety of losses, the most prevalent of which is bone mineral density loss, which can lead to severe osteoporotic fractures and impede geriatric mobility.[6]
- Higher risk of calcium deficit found in women after menopause as estrogen deficiency results in reduced intestinal calcium absorption and reabsorption by the kidneys; there is reduced fractional calcium absorption and increased parathyroid hormone secretion and bone resorption.
- Antinutrients in foods like tannins, oxalates, and phytates are familiar to produce insoluble calcium complex, resulting in decreased calcium absorption in intestine.
- Diet with high sodium is associated with magnified urinary excretion of calcium, resulting in lower calcium retention.[99]
- Calcium must be acidified before digestion in the geriatric because calcium absorption is reduced because of a lack of stomach HCl.
- Food sources include dairy and dairy products, commercially fortified foods, peas and dried beans, leafy green vegetables, tofu, and canned salmon.[98]
- Frequently, complete dentures wearer encounters a speedy and uncontrolled ridge resorption; can be linked to negative calcium balance, contributing osteoporosis.[100]

Iron

- Important functional component of various metabolisms like oxygen transport, harmful oxygen radical inactivation, oxidative energy production and synthesis of DNA. It acts as a cofactor in central nervous system for oxidative phosphorylation, neurotransmitter production, oxygen transport and nitric oxide metabolism; essential in neuroprotection and neuronal activities.[68]
- It's important in sustaining immune and antioxidant role in geriatric.[101] It impedes in conditions involving chronic inflammation, like obesity or aging because inflammation influence hepcidin, that modulates homeostasis of iron. Its further aggravates in malnutrition.[102,103]

- Postmenopausal women and older men have higher risk of iron deficit due to persistent loss of blood from disease conditions, reduced absorption due to decrease acid secretion, medications (antacids) usages, or low dietary iron and decreased food intake.[104]
- The body's inability with aging to continue equilibrium between iron stores and supply amplifies anemia condition. Iron deficit anemia, is associated with impaired cognitive performance, loss of muscle strength, symptoms of depression, lower life quality, and increased hospitalization and death rate in the geriatric.[103,105]
- Tannins, phytate, polyphenols, and calcium show an inhibitory function in iron absorption, while iron absorption enhances with vitamin C.[106]
- Intraorally, its deficit leads to burning tongue, anemia, and angular cheilosis.
- Iron deficit may be rectified by iron-adequate food and iron supplementation. In case of unresponsive of oral treatment, opt for intravenous iron replacement.[6]
- Iron-overloaded states, especially hemochromatosis, result in overabundance of liver iron, leading to excess iron-induced cell damage, cirrhosis, fibrosis and hepatocellular cancer and infection risks.[107] Iron chelation therapy can be treatment option.[6]
- Food sources include green leafy vegetables; whole grains; meat, fish, poultry; fortified breads and cereals; peas and dried beans.[106]

Zinc

- Intricated in DNA synthesis, transcription, signal transduction for immune cell function, enzymatic catabolism and metabolism of numerous micronutrients.
- Deficiency leads to a weakened immunity and impaired T cell-mediated functions, increasing infections risk.[108]
- Deficit also influences functioning of various nutrients, for example, retinol-binding protein synthesis is zinc-dependent; necessary for mobilizing vitamin A to plasma and liver's retinol. Low serum zinc accelerates vitamin E demand because of reduced intestinal absorption and decreases dietary folate absorption.[109] Its deficit is one of the reasons for ageusia, solidly influencing geriatric food consumption.[36]
- Decrease metallothionein synthesis causes zinc disparity in the intestine and other tissue, which is mainly due to inadequate intake of dietary zinc along with intrinsic and extrinsic factors.[6]
- Altered villus shape, mitochondrial changes, crypt elongation, collagen alterations and accelerated time for cryptal cell replication seriously alter geriatric zinc absorption. Other factors include poor food chewing, oral problems that limit food intake, various medications altering the absorption, and psychosocial factors that restrict diet consumption.[36]
- Food sources include beans; fortified cereals; nuts; seafood, poultry, red meat; whole grains and dairy products.[6]

Chromium

- Essential trace element.[110]
- Vital component of a dinicotinic acid glutathione complex; potentiate insulin action. Possible role in lipid metabolism.[111]
- It has been found to bind with DNA, causing abnormal synthesis of RNA in invitro study.[112] It has been suggested that impaired glucose tolerance and ischemic heart disease can be secondary to chromium deficit.[113,114]
- Risk increases in geriatric consuming inadequate chromium due to chewing insufficiency, anorexia, and no desire to cook, eating refined low chromium diet.
- Food sources include meats; grains; spices; vegetables; fruits and nuts.[110]

Copper

- Another essential mineral affected slightly by age.[38]
- Deficiency can increase fracture risk by decreasing bone strength.[115]
- Both copper and iron are essential as well as toxic metals. Except for the hereditary overload illnesses, Wilson's disease, and hemochromatosis, their toxicity is less well understood than their necessity.
- Both metals are transitional elements, and the development of oxidative energy production has made use of the redox properties that emerge from this. However, both causes overproduction of harmful oxidizing radicals.
- Overabundance of iron and copper can contribute to aging diseases like Alzheimer's and other neurodegenerative diseases, diabetes mellitus, arteriosclerosis, etc.[116]
- Elevated dietary zinc to copper ratio can be a contributory determinant in the coronary heart disease progression.[117]
- Food sources include dark leafy greens; oysters and other shellfish; whole grains; beans; nuts; potatoes; dried fruits like cocoa, black pepper; and yeast.[116]

Iodine

- One of the imperative trace elements for human development and health. Plays indispensable role in synthesis of thyroid hormones.[118]
- Even-though the unfavorable health outcome of iodine deficit is most conspicuous in the fetus and during infancy, unpropitious outcomes are observed at all stages of life.
- Adult's thyroid dysfunction is linked with dyslipidemia, hypertension, osteoporosis, cognitive impairment, muscle wasting, and weakness.
- Geriatrics vulnerability to iodine deficit or overabundance increases due to age-related thyroid function changes along with hyperthyroidism, hypothyroidism, and autoimmune thyroid disease.[118,119]
- Food sources may fluctuate correspondent to mineral content of soil where the edible is grown.[118]

Magnesium

- Crucial role in energy production, oxidative phosphorylation, glycolysis, synthesis of protein, and nucleic acid.[120]
- Participate in the synthesis of ATP to form MgATP in mitochondria.[121] Mg ions take part in the other ions

transit through cell membranes, muscle contraction, and neuron excitability control.
- Homeostasis of cellular Mg is linked to the other ions cellular metabolism, for example, K, Na, Ca; via $Na^+/K+$/ ATPase, Ca^{2+} activated K channels, and other mechanisms.[122]
- Optimal Mg balance continuity throughout life can assist in the blockage of oxidative stress and age-linked chronic diseases.
- Altered Mg balance may be due to high dietary Ca, Na, protein, caffeine/alcohol intake, and some medication like diuretics.
- Primarily deficit is because of insufficient dietary intake, reduced absorption, or accelerated urinary excretion or secondary to age-linked diseases and medications.[123]
- Clinical features are usually absent or non-specific like headache, anxiety, insomnia, fatigue, hyperemotionality, depressive symptoms, dizziness in moderate deficiency, while mild hypomagnesemia subjects are generally asymptomatic. Severe deficiency includes tremor, muscle fasciculation, weakness, dysphagia, positive-Trousseau's sign, orthostatic hypotension, and/or borderline hypertension.[124]
- Hypertension, cardiovascular diseases, and stroke, cardiometabolic syndrome and type 2 diabetes mellitus, airways constrictive syndromes and asthma, depression, stress-related conditions and psychiatric disorders, Alzheimer's disease and other dementia syndromes, bone fragility, muscular diseases and cancer are linked with its deficiency.
- Food sources include legumes, green leafy vegetables, whole grains, seeds, and nuts.[123]

Manganese

- Trace element essential for desirable biological functioning and as a cofactor for many enzymes.[125]
- Its deficiency is exceedingly rare due to abundance in dietary food.
- High Mn intake may result in emotional and psychological upsets and motor symptoms similar of Parkinson's disease, including tremor, gait disturbance, bradykinesia, and rigidity.
- Food sources include legumes, grains, green leafy vegetables, tea, rice, and fruits.[126]

Phosphorus

- Fundamental for life, as it aids in the cellular membranes as a component of phospholipids, ATP, and nucleic acids.
- Also plays significant aid in cellular signaling via phosphorylation reactions.
- Its equilibrium is influenced due to interactions between the intestine, parathyroid glands, bone, and kidney.[127] Its required in sufficient quantity for bone matrix calcium deposition and can trigger repair of bone.
- Its dietary deficiency is infrequent. However, if happens, hypophosphatemia may lead to cardiomyopathy, pseudomyopathy, and osteomalacia. Reduced intracellular phosphorus may influence energetic reactions like neurologic function, electrolyte balance, and muscle contraction due to reduced ATP supplies.
- Risk increases in geriatric due to decrease phosphorus absorption in cases of high antacids usages (aluminum hydroxide) used in peptic ulcers treatment.[38]
- Its high serum levels had shown linkage with smoking, hypertension, albuminuria, low estimated glomerular filtration rate (eGFR), and metabolic disorders.
- Food sources include dairy products, meats and poultry, fish, eggs, vegetables, grains, and nuts.[127]

Potassium

- Principal intracellular cation, chiefly implicated in nerve and muscle cells membrane potential and electrical excitation and acid-base regulation.[128]
- Nutritional deficiency is uncommon as it is widely present in plenty of foods plus potassium that is filtered by the kidney glomerulus is mostly reabsorbed all through the kidney tubules.[129]
- Subsequent to a series of underlying abnormalities in potassium equilibrium, the geriatric is particularly predisposed to develop hyperkalemia due to age-related decrease in GFR or interruption in renal tubular functions and renin angiotensin-aldosterone system activity; and medications like β-adrenergic blockers, nonsteroidal anti-inflammatory drugs, and angiotensin-converting enzyme inhibitors. The presence of long-standing hypertension, urinary obstruction, or diabetes frequently amplifies the risk.[130,131]
- Its appropriate management in the geriatric may dodge life-threatening neuromuscular and cardiac complications.[132]
- Food sources include green leafy and starchy vegetables, fruits, beans, nuts, and milk products.[128]

Sodium

- Essentially indulged in the normal cellular equilibrium maintenance and blood pressure, fluid, and electrolyte balance regulation.
- Plays imperative role in maintaining extracellular fluid volume due to its essential osmotic action and is essential for the muscle and nerve cells excitability and for transit of nutrients and substrates through plasma membranes.[133]
- Reduced serum sodium is a rather frequent electrolyte disorder in the geriatric due to the presence of determinants contributory to increased antidiuretic hormone, the recurring medications associated with hyponatremia and also because of other mechanisms such as the "tea and toast" syndrome.[134]
- Acute hyponatremia symptoms (<48 hour) include nausea, vomiting, headache, stupor, coma and seizures, as well as manifestations (even mild) associated with chronic hyponatremia, such as fatigue, cognitive impairment, gait deficits, falls, osteoporosis, and fractures.[133]
- Food sources include cereals and cereal products, meat, eggs, fish, and milk products.[134]

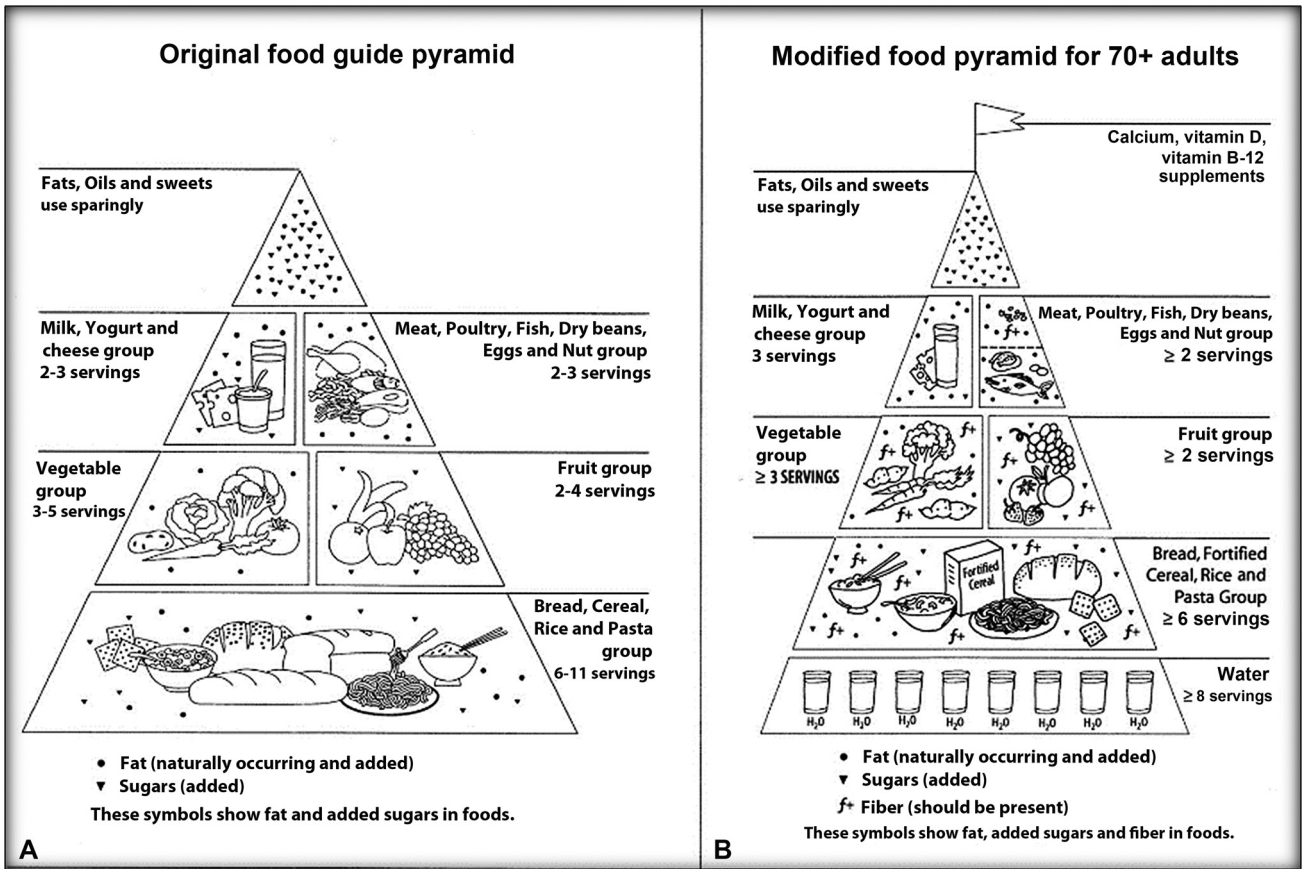

Fig. 1 (A) Initial food guide pyramid; (B) Revised food guide pyramid for people aged 70 and older.

Modified Food Guide Pyramid Diagram

For people aged 70 and older, the modified dietary pyramid has been designed, taking into account the unique demands of geriatrics (►**Fig. 1**). The updated Food Guide Pyramid for the elderly prioritizes nutrient-dense foods, fiber, and water while having a smaller baseline (representing decreased energy needs). Additionally, many geriatrics may benefit from nutrient-specific preparations.[135]

Assessment of Nutritional Status

Triphasic Nutritional Analysis

Phase I

Includes screening, gathering data from a sociomedical history, screening for clinical signs of nutritional inadequacy, taking a few anthropometric measurements, and assessing how well each individual diet is meeting their needs.

Qualitative Dietary Assessment

Evaluates a person's present and past eating patterns, as well as any recent dietary changes. Health care practitioners may give this questionnaire in both inpatient and outpatient settings.

Based on the overall score, it is possible to estimate the possible nutritional status; at a later time, nutritional assessment should go on to Phase II. The nutritional assessment should be conducted and the proper dietary counselling should be put into place if adequate information is available at the end of Phase I to ensure a rational basis for therapy.

Phase II

Additional information can be gathered if the identified score indicates a potential nutritional concern, according to the questionnaire. Additionally, semiquantitative nutritional assessment and regular blood tests must to be performed.

Semiquantitative Dietary Analysis

At this stage of examination, dietary intake is assessed using more quantitative techniques. Nutrient content of all foods and beverages consumed over a 3 to 5 days period is quantified using food composition tables or computer-aided nutritional analysis techniques.

Average calorie and nutrient consumption must be compared and quantified to norms. The aid of a licensed dietitian functioning as advisor is crucial at this level.

Biochemical Assessment

In addition to providing more definitive information about a patient's nutritional state, regular blood tests are valuable too.

Most indices, however, are frequently impacted by age-related declines in kidney function and body water. The

impacts of medications and persistent severe conditions exacerbate this decrease. These indices are within normal norms for younger people.

Phase III

This is for further complicated nutritional disorders and must be performed under the physician supervision. Thorough nutritional biochemical assessment of tissues, blood, and urine, as well as metabolic and endocrine function testing, is performed at this stage.[136]

Foods Recommended for the Geriatric Population

Eating a range of foods from the following five food groups in sufficient amounts will provide you with all the nutrients required for maximum health in the desired amounts:

1. Four portions of fruits and vegetables, divided into the following three categories:
   a. Two portions of diet rich in vitamin C, for example, raw cabbage, salad greens, and citrus fruits.
   b. One portion of a vitamin A rich diet, for example, yellow and dark green fruits and vegetables.
   c. One dish of fruits, vegetables, and potatoes.
2. Four portions of items made with enriched flour, cereal, and bread.
3. Two portions of milk and milk products, for example, cheese.
4. Two portions of high protein diet, for example, nonvegetarian products like meat, fish, poultry, and eggs, may be recommended. The greatest sources include dry beans, peas, and nuts as well.
5. Other unspecified items, for example, alcohol and fats, sweets, and oils; the sole portion suggestion is 2 to 4 tablespoons of polyunsaturated fats, which are a source of important fatty acids.[137]

Diet Recommended for New Denture Wearer

The typical process of biting, chewing, and swallowing food becomes slightly more challenging for an elderly person wearing fresh complete dentures. They may practice this eating schedule in reverse because it would be simpler for them. As a result, the geriatric should be advised to take a liquid diet in the days after receiving new dentures. Once more, a bland diet is advised over the following few days, which can be followed by a regular diet plan by the end of the week.[138]

First Day of Postinsertion

- Fruit-vegetable group: juices
- Bread-cereal group: gruels prepared in milk or water.
- Milk group: any form of liquid milk is acceptable. A glass of milk must be included on the sample menu at least once every day.
- Meat group: eggs in eggnogs, pureed meats, meat broths, or soups.

Second and Third Day of Postinsertion

- Fruit-vegetable group: juices; fruits and vegetables cooked tender.
- Bread-cereal group: rice, noodles, macaroni, soft baked breads, and cooked cereals.
- Milk group: cottage cheese and liquid milk. A glass of milk should be taken at least once every day, along with butter or margarine.
- Meat group: minced beef, thick soup, soft chicken or fish in cream sauce, scrambled eggs, etc.

Fourth Day and After

- Firmer foods can be taken in addition to the soft foods after the fourth day or as soon as the sore spots have healed. Before eating, it is best to cut them into little pieces. A glass of milk and butter or margarine must be included on the sample menu.[3]

Nutrition Counseling and Dietary Guidance for the Geriatric Population

- The geriatric is unable to meet its nutrient needs from dietary sources because to insufficient food intake. To meet this need, dietary supplements including multivitamins, protein, and minerals have been in high demand.[6] However, supplement use should be closely watched because consuming fortified foods together with supplements can increase the risk of going over the acceptable upper limit and toxicity.
- Due to the fact that denture fabrication requires a series of meetings, dietary analysis and counselling are easily incorporated into the treatment plan.
- Any serious deficient condition should prompt the patient to seek medical attention for more thorough diagnostic and therapeutic procedures. The dentist can offer the necessary advice when there is a blatant overconsumption of cariogenic or imbalanced diets that can cause issues, or when there are moderate clinical signs mixed with unsuitable dietary habits.[3]

Conclusion

Complete denture failure is frequently caused by the patient's dietary deficits. Consumption of low calorie, poor masticatory efficiency, the existence of a medical condition, socioeconomic position, and psychological disorders can all contribute to nutritional deficiencies. Correct eating habits, supplements, and adequate nutrient consumption as needed for maintaining proper health, as well as addressing serious deficiencies or referring the patient for care, are all options for prevention and treatment. A patient with dentures is unlikely to make drastic dietary adjustments, but if the necessity is adequately emphasized, they will add nutritionally vital foods. Correct dietary changes have the ability to improve the health of the geriatric. As a result, additional attention must be paid to geriatric health to maintain it and to reduce the chronic diseases prevalence.

Conflict of Interest
None declared.

References

1 Zarb GA, Hobkirk J, Eckert S, Jacob R. Prosthodontics Treatment for Edentulous Patients: Complete Dentures and Implant Supported Prostheses. 13th edition. St. Louis Missouri, US: Mosby Inc; 2012
2 Atwood DA. Reduction of residual ridges: a major oral disease entity. J Prosthet Dent 1971;26(03):266–279
3 Bandodkar KA, Aras M. Nutrition for geriatric denture patients. J Indian Prosthodont Soc 2006;6(01):22–28
4 Ramsey WO. The role of nutrition in conditioning edentulous patients. J Prosthet Dent 1970;23(02):130–135
5 Sanford AM. Anorexia of aging and its role for frailty. Curr Opin Clin Nutr Metab Care 2017;20(01):54–60
6 Kaur D, Rasane P, Singh J, et al. Nutritional interventions for elderly and considerations for the development of geriatric foods. Curr Aging Sci 2019;12(01):15–27
7 Visvanathan R. Anorexia of aging. Clin Geriatr Med 2015;31(03): 417–427
8 de Boer A, Ter Horst GJ, Lorist MM. Physiological and psychosocial age-related changes associated with reduced food intake in older persons. Ageing Res Rev 2013;12(01):316–328
9 Landi F, Calvani R, Tosato M, et al. Anorexia of aging: risk factors, consequences, and potential treatments. Nutrients 2016;8(02):69
10 Martone AM, Onder G, Vetrano DL, et al. Anorexia of aging: a modifiable risk factor for frailty. Nutrients 2013;5(10): 4126–4133
11 Grassi M, Petraccia L, Mennuni G, et al. Changes, functional disorders, and diseases in the gastrointestinal tract of elderly. Nutr Hosp 2011;26(04):659–668
12 Krall E, Hayes C, Garcia R. How dentition status and masticatory function affect nutrient intake. J Am Dent Assoc 1998;129(09): 1261–1269
13 Gombart AF, Pierre A, Maggini S. A review of micronutrients and the immune system-Working in harmony to reduce the risk of infection. Nutrients 2020;12(01):236
14 El-Kadiki A, Sutton AJ. Role of multivitamins and mineral supplements in preventing infections in elderly people: systematic review and meta-analysis of randomised controlled trials. BMJ 2005;330(7496):871
15 Rodriguez RM. Psychosocial issues in geriatric rehabilitation. Phys Med Rehabil Clin N Am 2017;28(04):693–704
16 Horowitz A. Depression and vision and hearing impairments in later life. J Am Soc Aging. 2003;27(01):32–38
17 Fisher DE, Ward MM, Hoffman HJ, Li CM, Cotch MF. Impact of sensory impairments on functional disability in adults with arthritis. Am J Prev Med 2016;50(04):454–462
18 Dagli RJ, Sharma A. Polypharmacy: a global risk factor for elderly people. J Int Oral Health 2014;6(06):i–ii
19 Hajjar ER, Cafiero AC, Hanlon JT. Polypharmacy in elderly patients. Am J Geriatr Pharmacother 2007;5(04):345–351
20 Anil S, Vellappally S, Hashem M, Preethanath RS, Patil S, Samaranayake LP. Xerostomia in geriatric patients: a burgeoning global concern. J Investig Clin Dent 2016;7(01):5–12
21 Gaines AD. Anosmia and hyposmia. Allergy Asthma Proc 2010; 31(03):185–189
22 Smoliner C, Fischedick A, Sieber CC, Wirth R. Olfactory function and malnutrition in geriatric patients. J Gerontol A Biol Sci Med Sci 2013;68(12):1582–1588
23 Fisher WT. Prosthetics and geriatric nutrition. J Prosthet Dent 1955;5(02):481–485
24 Clark D, Kotronia E, Ramsay SE. Frailty, aging, and periodontal disease: basic biologic considerations. Periodontol 2000 2021;87 (01):143–156
25 Moynihan P, Bradbury J. Compromised dental function and nutrition. Nutrition 2001;17(02):177–178
26 Marshall TA, Warren JJ, Hand JS, Xie XJ, Stumbo PJ. Oral health, nutrient intake and dietary quality in the very old. J Am Dent Assoc 2002;133(10):1369–1379
27 Chai J, Chu FCS, Chow TW, Shum NC, Hui WWH. Influence of dental status on nutritional status of geriatric patients in a convalescent and rehabilitation hospital. Int J Prosthodont 2006;19(03):244–249
28 Kapur KK, Soman SD. Masticatory performance and efficiency in denture wearers. 1964. J Prosthet Dent 2004;92(02):107–111
29 Fontijn-Tekamp FA, Slagter AP, Van Der Bilt A, et al. Biting and chewing in overdentures, full dentures, and natural dentitions. J Dent Res 2000;79(07):1519–1524
30 Manly RS, Braley LC. Masticatory performance and efficiency. J Dent Res 1950;29(04):448–462
31 Yurkstas A, Emerson WH. Decreased masticatory function in denture patients. J Prosthet Dent 1964;14(05):931–934
32 van der Bilt A. Assessment of mastication with implications for oral rehabilitation: a review. J Oral Rehabil 2011;38(10):754–780
33 Slagter AP, Bosman F, Van der Bilt A. Comminution of two artificial test foods by dentate and edentulous subjects. J Oral Rehabil 1993;20(02):159–176
34 Johansson A, Unell L, Johansson AK, Carlsson GE. A 10-year longitudinal study of self-assessed chewing ability and dental status in 50-year-old subjects. Int J Prosthodont 2007;20(06): 643–645
35 Speksnijder CM, Abbink JH, van der Glas HW, Janssen NG, van der Bilt A. Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. Eur J Oral Sci 2009;117(05):580–586
36 Mocchegiani E, Romeo J, Malavolta M, et al. Zinc: dietary intake and impact of supplementation on immune function in elderly. Age (Dordr) 2013;35(03):839–860
37 Nutrient recommendations: Dietary Reference Intake (DRI). Accessed August 27, 2022, at: https://ods.od.nih.gov/HealthInformation/Dietary_Reference_Intakes.aspx
38 Bidlack WR, Smith CH. Nutritional requirements of the aged. Crit Rev Food Sci Nutr 1988;27(03):189–218
39 Calloway DH, Zanni E. Energy requirements and energy expenditure of elderly men. Am J Clin Nutr 1980;33(10):2088–2092
40 Hrachovec JP. Health maintenance in older adults. J Am Geriatr Soc 1969;17(05):433–450
41 Watkin DM. The physiology of aging. Am J Clin Nutr 1982;36(04): 750–758
42 Adams GM, DeVries HA. Physiological effects of an exercise training regimen upon women aged 52 to 79. J Gerontol 1973; 28(01):50–55
43 De Vries HA. Physiological effects of an exercise training regimen upon men aged 52 to 88. J Gerontol 1970;25(04):325–336
44 Kohrs MB. Introduction: symposium on nutrition and aging. Am J Clin Nutr 1982;36(04):735–736
45 Tuttle SG, Swendseid ME, Mulcare D, Griffith WH, Bassett SH. Study of the essential amino acid requirements of men over fifty. Metabolism 1957;6(6 Pt 1):564–573
46 Gaffney-Stomberg E, Insogna KL, Rodriguez NR, Kerstetter JE. Increasing dietary protein requirements in elderly people for optimal muscle and bone health. J Am Geriatr Soc 2009;57(06): 1073–1079
47 Morley JE, Argiles JM, Evans WJ, et al; Society for Sarcopenia, Cachexia, and Wasting Disease. Nutritional recommendations for the management of sarcopenia. J Am Med Dir Assoc 2010;11 (06):391–396
48 Baum JI, Kim IY, Wolfe RR. Protein consumption and the elderly: what is the optimal level of intake? Nutrients 2016;8(06):359
49 Bauer J, Biolo G, Cederholm T, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a

position paper from the PROT-AGE Study Group. J Am Med Dir Assoc 2013;14(08):542–559
50 Albanese AA. Nutrition for the Elderly. 1st edition. New York: Alan R Liss; 1980
51 Savaiano DA, Levitt MD. Milk intolerance and microbe-containing dairy foods. J Dairy Sci 1987;70(02):397–406
52 Gallagher CR, Molleson AL, Caldwell JH. Lactose intolerance and fermented dairy products. J Am Diet Assoc 1974;65(04):418–419
53 Andres R. Aging and diabetes. Med Clin North Am 1971;55(04): 835–846
54 Horwitz DL. Diabetes and aging. Am J Clin Nutr 1982;36(04): 803–808
55 Ha MA, Jarvis MC, Mann JI. A definition for dietary fibre. Eur J Clin Nutr 2000;54(12):861–864
56 Roberfroid MB. Prebiotics and probiotics: are they functional foods? Am J Clin Nutr 2000;71(6, Suppl):1682S–1687S, discussion 1688S–1690S
57 Moreyra AE, Wilson AC, Koraym A. Effect of combining psyllium fiber with simvastatin in lowering cholesterol. Arch Intern Med 2005;165(10):1161–1166
58 Ziai SA, Larijani B, Akhoondzadeh S, et al. Psyllium decreased serum glucose and glycosylated hemoglobin significantly in diabetic outpatients. J Ethnopharmacol 2005;102(02):202–207
59 O'Keefe SJD. Nutrition and colonic health: the critical role of the microbiota. Curr Opin Gastroenterol 2008;24(01):51–58
60 Tuohy KM, Probert HM, Smejkal CW, Gibson GR. Using probiotics and prebiotics to improve gut health. Drug Discov Today 2003;8 (15):692–700
61 Donini LM, Savina C, Cannella C. Nutrition in the elderly: role of fiber. Arch Gerontol Geriatr 2009;49(1, Suppl 1):61–69
62 Williams ME, Pannill FC III. Urinary incontinence in the elderly: physiology, pathophysiology, diagnosis, and treatment. Ann Intern Med 1982;97(06):895–907
63 Yarnell JW, St Leger AS. The prevalence, severity and factors associated with urinary incontinence in a random sample of the elderly. Age Ageing 1979;8(02):81–85
64 Phillips PA, Rolls BJ, Ledingham JG, et al. Reduced thirst after water deprivation in healthy elderly men. N Engl J Med 1984;311 (12):753–759
65 Leaf A. Dehydration in elderly. N Engl J Med 1984;311(12): 791–792
66 Ellis FP, Exton-Smith AN, Foster KG, Weiner JS. Eccrine sweating and mortality during heat waves in very young and very old persons. Isr J Med Sci 1976;12(08):815–817
67 Thomas DR. Vitamins in aging, health, and longevity. Clin Interv Aging 2006;1(01):81–91
68 Watson J, Lee M, Garcia-Casal MN. Consequences of inadequate intakes of vitamin A, vitamin B_{12}, vitamin D, calcium, iron, and folate in older persons. Curr Geriatr Rep 2018;7(02):103–113
69 Beydoun MA, Shroff MR, Beydoun HA, Zonderman AB. Serum folate, vitamin B-12, and homocysteine and their association with depressive symptoms among U.S. adults. Psychosom Med 2010;72(09):862–873
70 Kennedy DO. B vitamins and the brain: mechanisms, dose and efficacy-a review. Nutrients 2016;8(02):68
71 Sturtzel B, Dietrich A, Wagner KH, Gisinger C, Elmadfa I. The status of vitamins B6, B12, folate, and of homocysteine in geriatric home residents receiving laxatives or dietary fiber. J Nutr Health Aging 2010;14(03):219–223
72 Allen LH. How common is vitamin B-12 deficiency? Am J Clin Nutr 2009;89(02):693S–696S
73 Wiley KD, Gupta M. Vitamin B1 Thiamine Deficiency. 1st edition. Treasure Island (FL): Stat Pearls Publishing; 2022
74 Ryan-Harshman M, Aldoori W. Carpal tunnel syndrome and vitamin B6. Can Fam Physician 2007;53(07):1161–1162
75 Ribaya-Mercado JD, Russell RM, Sahyoun N, Morrow FD, Gershoff SN. Vitamin B-6 requirements of elderly men and women. J Nutr 1991;121(07):1062–1074
76 Kjeldby IK, Fosnes GS, Ligaarden SC, Farup PG. Vitamin B6 deficiency and diseases in elderly people–a study in nursing homes. BMC Geriatr 2013;13(01):13
77 Andrès E, Loukili NH, Noel E, et al. Vitamin B12 (cobalamin) deficiency in elderly patients. CMAJ 2004;171(03):251–259
78 Thomas DR. Anemia and quality of life: unrecognized and undertreated. J Gerontol A Biol Sci Med Sci 2004;59(03): 238–241
79 Ho RCM, Cheung MWL, Fu E, et al. Is high homocysteine level a risk factor for cognitive decline in elderly? A systematic review, meta-analysis, and meta-regression. Am J Geriatr Psychiatry 2011;19(07):607–617
80 Kim J, Kim MJ, Kho HS. Oral manifestations in vitamin B12 deficiency patients with or without history of gastrectomy. BMC Oral Health 2016;16(01):60
81 Marriott BP, Birt DF, Stallings VA, Yates AA. Present Knowledge in Nutrition: Basic Nutrition and Metabolism. 11th edition. Washington, DC: Elsevier; 2020
82 Watanabe F, Yabuta Y, Bito T, Teng F. Vitamin B_{12}-containing plant food sources for vegetarians. Nutrients 2014;6(05): 1861–1873
83 Damayanti D, Jaceldo-Siegl K, Beeson WL, Fraser G, Oda K, Haddad EH. Foods and supplements associated with vitamin B12 biomarkers among vegetarian and non-vegetarian participants of the Adventist Health Study-2 (AHS-2) Calibration study. Nutrients 2018;10(06):722
84 Giovannucci E, Stampfer MJ, Colditz GA, et al. Multivitamin use, folate, and colon cancer in women in the Nurses' Health Study. Ann Intern Med 1998;129(07):517–524
85 Kwon J, Suzuki T, Yoshida H, Kim H, Yoshida Y, Iwasa H. Concomitant lower serum albumin and vitamin D levels are associated with decreased objective physical performance among Japanese community-dwelling elderly. Gerontology 2007;53(05):322–328
86 Ness AR, Powles JW. Fruit and vegetables, and cardiovascular disease: a review. Int J Epidemiol 1997;26(01):1–13
87 Genkinger JM, Platz EA, Hoffman SC, Comstock GW, Helzlsouer KJ. Fruit, vegetable, and antioxidant intake and all-cause, cancer, and cardiovascular disease mortality in a community-dwelling population in Washington County, Maryland. Am J Epidemiol 2004;160(12):1223–1233
88 Yokoyama T, Date C, Kokubo Y, Yoshiike N, Matsumura Y, Tanaka H. Serum vitamin C concentration was inversely associated with subsequent 20-year incidence of stroke in a Japanese rural community. The Shibata study. Stroke 2000;31(10):2287–2294
89 Riccioni G, D'Orazio N, Salvatore C, Franceschelli S, Pesce M, Speranza L. Carotenoids and vitamins C and E in the prevention of cardiovascular disease. Int J Vitam Nutr Res 2012;82(01): 15–26
90 Preedy V. Aging: Oxidative Stress and Dietary Antioxidants. 1st edition. Cambridge, US: Academic Press Inc.; 2014
91 Fortmann SP, Burda BU, Senger CA, Lin JS, Whitlock EP. Vitamin and mineral supplements in the primary prevention of cardiovascular disease and cancer: an updated systematic evidence review for the U.S. Preventive Services Task Force. Ann Intern Med 2013;159(12):824–834
92 Skaaby T. The relationship of vitamin D status to risk of cardiovascular disease and mortality. Dan Med J 2015;62(02):B5008
93 Mizwicki MT, Menegaz D, Zhang J, et al. Genomic and non-genomic signaling induced by 1α,25(OH)2-vitamin D3 promotes the recovery of amyloid-β phagocytosis by Alzheimer's disease macrophages. J Alzheimers Dis 2012;29(01):51–62
94 Nordin BEC, Need AG, Morris HA, O'Loughlin PD, Horowitz M. Effect of age on calcium absorption in postmenopausal women. Am J Clin Nutr 2004;80(04):998–1002
95 Lips P, Bouillon R, van Schoor NM, et al. Reducing fracture risk with calcium and vitamin D. Clin Endocrinol (Oxf) 2010;73(03): 277–285

96 Booth SL. Vitamin K status in the elderly. Curr Opin Clin Nutr Metab Care 2007;10(01):20–23
97 Simes DC, Viegas CSB, Araújo N, Marreiros C. Vitamin K as a powerful micronutrient in aging and age-related diseases: pros and cons from clinical studies. Int J Mol Sci 2019;20(17):4150
98 Beto JA. The role of calcium in human aging. Clin Nutr Res 2015;4 (01):1–8
99 Zhu K, Prince RL. Calcium and bone. Clin Biochem 2012;45(12): 936–942
100 Barone JV. Nutrition–phase one of the edentulous patient. J Prosthet Dent 1978;40(02):122–126
101 Mocchegiani E, Costarelli L, Giacconi R, Piacenza F, Basso A, Malavolta M. Micronutrient (Zn, Cu, Fe)-gene interactions in ageing and inflammatory age-related diseases: implications for treatments. Ageing Res Rev 2012;11(02):297–319
102 Dao MC, Meydani SN. Iron biology, immunology, aging, and obesity: four fields connected by the small peptide hormone hepcidin. Adv Nutr 2013;4(06):602–617
103 Fairweather-Tait SJ, Wawer AA, Gillings R, Jennings A, Myint PK. Iron status in the elderly. Mech Ageing Dev 2014;136-137:22–28
104 Mason JB, Tang SY. Folate status and colorectal cancer risk: A 2016 update. Mol Aspects Med 2017;53(01):73–79
105 Goodnough LT, Schrier SL. Evaluation and management of anemia in the elderly. Am J Hematol 2014;89(01):88–96
106 Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. J Res Med Sci 2014;19(02): 164–174
107 Anderson ER, Shah YM. Iron homeostasis in the liver. Compr Physiol 2013;3(01):315–330
108 Barnett JB, Dao MC, Hamer DH, et al. Effect of zinc supplementation on serum zinc concentration and T cell proliferation in nursing home elderly: a randomized, double-blind, placebo-controlled trial. Am J Clin Nutr 2016;103(03):942–951
109 Intorre F, Polito A, Andriollo-Sanchez M, et al. Effect of zinc supplementation on vitamin status of middle-aged and older European adults: the ZENITH study. Eur J Clin Nutr 2008;62(10): 1215–1223
110 Bunker VW, Lawson MS, Delves HT, Clayton BE. The uptake and excretion of chromium by the elderly. Am J Clin Nutr 1984;39 (05):797–802
111 Prasad AS. Clinical, Biochemical and Nutritional Aspects of Trace Elements. 1st edition. New York, US: Alan R Liss, Inc.; 1982
112 Okada S, Taniyama M, Ohba H. Mode of enhancement in ribonucleic acid synthesis directed by chromium (III)-bound deoxyribonucleic acid. J Inorg Biochem 1982;17(01):41–49
113 Glinsmann WH, Mertz W. Effect of trivalent chromium on glucose tolerance. Metabolism 1966;15(06):510–520
114 Schroeder HA. The role of trace elements in cardiovascular diseases. Med Clin North Am 1974;58(02):381–396
115 Conlan D, Korula R, Tallentire D. Serum copper levels in elderly patients with femoral-neck fractures. Age Ageing 1990;19(03): 212–214
116 Brewer GJ. Risks of copper and iron toxicity during aging in humans. Chem Res Toxicol 2010;23(02):319–326
117 Burke DM, DeMicco FJ, Taper LJ, Ritchey SJ. Copper and zinc utilization in elderly adults. J Gerontol 1981;36(05):558–563
118 Malavolta M, Mocchegiani E. Molecular Basis of Nutrition and Aging: A Volume in the Molecular Nutrition Series. 1st edition. Cambridge, US: Academic Press Inc.; 2016
119 Laurberg P, Cerqueira C, Ovesen L, et al. Iodine intake as a determinant of thyroid disorders in populations. Best Pract Res Clin Endocrinol Metab 2010;24(01):13–27
120 Saris NE, Mervaala E, Karppanen H, Khawaja JA, Lewenstam A. Magnesium. An update on physiological, clinical and analytical aspects. Clin Chim Acta 2000;294(1-2):1–26
121 Barbagallo M, Dominguez LJ. Magnesium metabolism in type 2 diabetes mellitus, metabolic syndrome and insulin resistance. Arch Biochem Biophys 2007;458(01):40–47
122 Resnick LM, Barbagallo M, Dominguez LJ, Veniero JM, Nicholson JP, Gupta RK. Relation of cellular potassium to other mineral ions in hypertension and diabetes. Hypertension 2001;38(3 Pt 2):709–712
123 Barbagallo M, Veronese N, Dominguez LJ. Magnesium in aging, health and diseases. Nutrients 2021;13(02):463
124 Flink EB. Magnesium deficiency. etiology and clinical spectrum. Acta Med Scand Suppl 1981;647(01):125–137
125 Aschner M. Manganese: brain transport and emerging research needs. Environ Health Perspect 2000;108(Suppl 3):429–432
126 Parmalee NL, Aschner M. Manganese and aging. Neurotoxicology 2016;56(01):262–268
127 Raikou VD, Kyriaki D, Gavriil S. Importance of serum phosphate in elderly patients with diabetes mellitus. World J Diabetes 2020; 11(10):416–424
128 Lanham-New SA, Lambert H, Frassetto L. Potassium. Adv Nutr 2012;3(06):820–821
129 Rose BD, Post TW. Clinical Physiology of Acid-Base and Electrolyte Disorders. 4th edition. New York, US: McGraw-Hill; 1994
130 Michelis MF. Hyperkalemia in the elderly. Am J Kidney Dis 1990; 16(04):296–299
131 Choi MJ, Fernandez PC, Patnaik A, et al. Brief report: trimethoprim-induced hyperkalemia in a patient with AIDS. N Engl J Med 1993;328(10):703–706
132 Perazella MA, Mahnensmith RL. Hyperkalemia in the elderly: drugs exacerbate impaired potassium homeostasis. J Gen Intern Med 1997;12(10):646–656
133 Strazzullo P. Sodium. Adv Nutr 2014;5(02):188–190
134 Filippatos TD, Makri A, Elisaf MS, Liamis G. Hyponatremia in the elderly: challenges and solutions. Clin Interv Aging 2017; 12:1957–1965
135 Russell RM, Rasmussen H, Lichtenstein AH. Modified Food Guide Pyramid for people over seventy years of age. J Nutr 1999;129 (03):751–753
136 De Paola DP, Alfano MC. Triphasic nutritional analysis and dietary counseling. Dent Clin North Am 1976;20(03):613–633
137 Palmer CA. Gerodontic nutrition and dietary counseling for prosthodontic patients. Dent Clin North Am 2003;47(02):355–371
138 Mich Detroit. Nutrition for the denture patient. J Prosthet Dent 1960;10(01):53–60

